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by

LaMar St.John

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Feasibility Study for the Development of a Computer-Based BLM - Wildland Fire Simulator

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WHAT IS A SIMULATION:

As the name implies, a simulation is an operating model that faithfully simulates the central features or elements in a real or proposed system, process, or environment.

A simulation also:

* Is dynamic as opposed to static;
* Includes only selected elements of the referent system (what is left out is as important as what is put in);
* Includes different types of referent systems. The user can simulate running a business, a manufacturing process, an office procedure, or any environmental scenario.

Because the participants in a simulation interact with the program by making decisions, simulations also include such features as: playing roles, achieving goals, and performing activities with constraints and payoffs both positive and negative. By manipulating the behavior of parts of a model, the user can see the effects of these changes on other parts of the model and on the model as a whole (Haslam, 1990).

SIMULATIONS FOR TRAINING:

Many people think of simulations as expensive, high-technology devices that create a kind of artificial reality for participants. Flight Simulators train pilots before they ever leave the ground. The medical and health care industries use high-end simulations with full-motion video for developing diagnostic skills. Educators and universities are also finding that simulations are powerful tools for learning, particularly in the sciences, mathematics, and psychology.

But, as microcomputers have become more powerful, the development of simulations for industrial training has greatly increased. Corporations use simulations that feature decision-making and management skills in realistic

scenarios. Insurance companies are training tellers and credit analysts in on-line tasks and customer service via simulations.

Simulations offer a number of benefits to the training process.

* The training in interactive simulations is dynamic, rather than static. By making decisions and hypothetical choices, the student is active, engaged, and autonomous. As students take control of learning, they are no longer passive, but actively enjoying and constructing knowledge.

* Training time is reduced while competency increases. When students are placed in intensive simulated environments to manipulate variables, the performance development that occurs is rapid and intense. By simulating all the tasks of a job the student can have an apprenticeship in days that would ordinarily take many months on the job.

* Training costs can be reduced dramatically over time. Simulation-based CBT has reduced up-front training time to more on-demand training, while lowering the turnover rate in the process.

And as training programs use assessment measures built into the simulation to pinpoint areas that need improvement, the training program becomes cost efficient (Haslam, 1990).

REQUIREMENTS OF A BLM WILDLAND FIRE SIMULATOR:

In order for a training simulation to meet the needs of BLM's fire community, in addition to the benefits mentioned above, it must also be:

Portable:

To allow the simulation to be installed or moved to field locations for utilization.

Operated by no more than one instructor:

The ideal would be for the simulation to require no instructor support at all. But some realism is lost when a computer terminal is placed in front of the trainee instead of a portable radio. The radio being the instrument of communication during the actual incident.

Random access of actual fire scenes:

Seeing the intensity of actual fire footage, such as a crown fire or a wind driven range fire, adds to the intensity of the training. It also provides a recognition factor for the trainee, to help recognize and respond to fire behavior.

Random access voice responses for computer-generated text:

Using computer-based training can result in many text screens of information and/or instruction being generated on a monitor for the trainee to read and respond to. The learning process is faster and more complete when the visual information is supported or reinforced by audio. Having a narrator read the information at the same time as the trainee, results in better comprehension of the material. Especially, if the trainee is a slow reader or has difficulty reading English.

Graphic representation of fire growth and resources at risk:

The trainee needs to be constantly aware of the movement and intensity of the fire; where the fire is in relation to resources that may be at risk; where the suppression resources are and the effect they are having on the fire; and many other aspects of the incident which require constant review by the trainee in order to make proper decisions.

Individualized instruction based on trainee input:

Within the BLM, as with most organizations, our people have varying levels of expertise. An effective fire simulation must provide for the more experienced to deal less with the basics and experience more difficult situations. The less experienced need to, based on their own inputs, concentrate more on the basics and receive more help and assistance.

Provide trainee with an overall performance evaluation:

It would be difficult in a simulation environment to give a grade such as A, B, or C. But a summary of performance should be provided to include such things as the number of acres burned, resources at risk, resources lost, suppression resources utilized, etc. If proper suppression tactics are not used the acres burned and resources lost would normally by very high. A local subject matter expert or instructor could also provide a verbal evaluation.

EXAMPLES OF SIMULATORS CURRENTLY BEING USED FOR TRAINING:

Flight Simulators:

Instead of lecturing pilots on "what to do if...," demonstrations can be provided with a very high degree of realism.

The more expensive the airplane is to operate, the greater the value of simulator training. Although converting simulators to meet FAA specifications is expensive, the cost is about one-tenth that of in-flight training.

Scenarios can be conducted in real time with a complete flight crew or in accelerated time. They are designed to be as close to real flight conditions as possible. Intermediate stops along a route are planned; weather conditions can be varied; and other en-route conditions requiring the pilot to demonstrate total understanding of concepts, procedures and systems are built into a scenario. Including the emergency maneuvers that may be expected in line operations.

Are pilots better trained in the all-electronic environment than in actual aircraft? In economic terms, the answer is definitely yes. Discounting the cost of the simulator, which is less than an actual aircraft, simulator training is free from air traffic control restrictions, fuel costs, weather conditions, aircraft availability and crashes. In addition to saving dollars by not using aircraft for training, the airline profits from the productivity of the pilot by sharply reducing the time needed to qualify. A pilot can practice landing a new type of aircraft many more times per hour in a simulator than in a real plane.

In terms of flight safety, it is more difficult to say that advanced simulator training is actually better. But the failure rate of pilots in transition training has declined since the introduction of simulator training.

In the late 1960's or early 1970's, when studies showed that training in flight simulators could ensure complete transfer of training to the aircraft, the FAA permitted simulator training as a substitute for certain in-flight training. By 1978, visual flight simulators using computer-generated image systems were so advanced that the FAA extended credit for landing maneuvers performed in simulators that had adequate aerodynamic programming (Condon, 1984).

Nuclear Power Facilities

Training simulators are helping to prevent accidents like those at Three Mile Island (TMI) and Chernobyl. At nuclear power facilities across the nation, some of the most sophisticated and costliest computer-based simulators in existence are training new plant operators to handle every conceivable situation they might encounter in the real reactor.

At a cost of $12 million, a computer-based simulator mirrors the reactor control room of the Seabrook Station nuclear plant in Seabrook, New Hampshire, down to the finest detail. The attempt is to copy the reactor room until there is full fidelity between the training control room and the real control room.

When the trainee flips a switch on the mock control board, the computer simulator executes a program that generates the response that would occur in the real Seabrook control room. Readouts for flow, pressure, and temperature react just as they would in the actual situation.

Site-specific simulators for training nuclear power plant personnel gained recognition after the Three Mile Island accident, when the Nuclear Regulatory Commission examined training procedures. Before that time, new personnel were typically sent to off-site training facilities where they practiced the intricacies of power plant operation on "generic" simulators. Today, nearly all nuclear power plants have adopted their own site-specific CBT programs.

Trainees start with the normal operations of the plant, then deal with simple malfunctions, multiple malfunctions, and finally accident scenarios. It's an evolutionary progression from normal to emergency procedures.

Before the simulator was developed, the nuclear reactor had to be shut down to test the trainees, a time consuming and expensive undertaking. Now, the training process never stops. After every six weeks of work in the reactor room, licensed operators are brought back to the training facility for a full week. They are re-tested on safety and emergency procedures annually.

There have been no accidents since TMI. Site-specific training may not be solely responsible for this, but it clearly reduces the potential for accident. The bottom line is that operators are better trained (Cummings, 1989).

The F-15 Situation Simulator for Firefighters:

This simulation is designed to improve the decision-making skills and response time of more than 10,000 Air Force firefighters who are called upon to extinguish fires on aircraft that suffer mishaps while landing, specifically the F-15 fighter plane.

Live training exercises pose a variety of problems for the Air Force and its firefighters. First of all, burning $25 million aircraft is not practical for economical and environmental reasons. Second, when older planes are sacrificed, it is impossible to control all the variables and the firefighters are exposed to random fire and rescue-related problems. Many firefighters will never see a real F-15 at their base until an emergency situation arises. They, therefore, have no opportunity to learn the intricacies of fighting fires on this type of aircraft.

Interactive simulations offer solutions to many of these problems. The program can train individuals in standard procedures, as well as some of the more obscure aspects of their jobs.

The user has the opportunity to experience a spectrum of problems and variables that would be impossible to stage. The program keeps track of each decision the user makes during the simulation, and at the conclusion of the simulation, the system delivers both an overall performance rating and evaluation of the user's execution or judgment during the exercise.

The F-15 Situation Simulator for Firefighters provides a tutorial, covering general fire fighting techniques, pilot rescue procedures, and some of the distinctive characteristics of the F-15. This is followed by multiple choice questions on the aircraft, fire fighting procedures, and tactics. And finally, a choice of three emergency simulation tracks: firefighter, rescue squad member, or crew chief/incident commander. The simulation generates a new situation each time it is used.

The Air Force's experience with the F-15 Situation Simulator for Firefighters has shown that training for highly procedural and dangerous work can be accomplished using interactive simulations. The Air Force expects the training to apply to all fighter aircraft (Hamilton, 1988).

Nursing Education

Today, there are more than 200,000 students in schools of nursing and just over two million nurses in practice. Their learning needs range from basic skill training and patient

care practice to updating and refining nursing skills. Because of the shortage of nurses and training staff, Interactive Videodisc (IVD) simulations have provided great benefit for student nurses and nurses in practice.

Nurse educators are using IVD simulations to teach basic skills and nursing content, and to provide simulated patient care experiences. Repetitive teaching tasks such as annual certifications, orientation, and mandatory educational programs are also being delegated to IVD. The interest and enthusiasm of nurse educators over the use of IVD simulations is extraordinary.

Today, patients are being discharged quicker from hospitals than in the past, making many fundamental student experiences unavailable. The development of patient care simulations can provide beginning experiences for novices as well as opportunities to practice caring for progressively complex patients as students advance.

Today, nurses in many areas of the hospital and nurses caring for patients in their homes are required to use new skills, such as interpreting electrocardiograms and arterial blood gases and monitoring patients on ventilators. Additional knowledge and skills must be learned to care for the increasing number of patients with AIDS and the growing population of the elderly. Nurse educators, however, insist that there is no room for additional content in an already impacted curriculum. And because of the nursing shortage, educators in clinical settings find it impossible to pull a group of staff nurses away from patient care for inservice programs to update their skills.

Tutorials using IVD simulation make it possible to comfortably incorporate additional learning requirements. Learning time is reduced by one-third to one-half with computer-assisted instruction, compared to traditional instructional methods. An additional benefit is that learning time can be scheduled around the clock for only one or two students at a time.

Because of the nursing shortage, recruitment, hiring, and orientation of new employees have become important issues. One Florida hospital has computerized its orientation program so that hiring new staff is not dependent on the next scheduled orientation. Experienced nurses can move through the program quickly and become productive sooner. A Texas hospital reports that orientation time is reduced by half when computer-assisted instruction is incorporated.

Learning time can be further reduced because IVD instruction is self-paced and can be individualized. Unlike traditional

classroom instruction, the use of IVD reduces redundancy for the more experienced. Self-paced individualization also assures mastery for those unfamiliar subjects through unrestricted repetition.

Nurse educators expect the delivery of education to be different in the year 2000. They also recognize that to get from today to tomorrow changes are inevitable. When change is accepted and expected, it occurs more rapidly. Thus, the next ten years should see even stronger movement toward the widespread use of technology in nursing education (Bolwell, 1990).

PARALLELS TO WILDLAND FIRE TRAINING:

The above examples of successful use of simulations all involve professional fields where mistakes are costly and even life threatening. Mistakes in wildland fire suppression are likewise costly and life threatening and could benefit from similar training.

These training simulations can serve as models for a variety of training requirements. Finding the most efficient, effective way of ensuring performance would well serve the training industry as a whole.

There is more than one way to accomplish a training task, and identifying and implementing the most suitable techniques should involve the full range of any trainer's expertise. The goal is to deliver consistent, high-quality training to trainees whose actions determine the fates of others.

It should be noted that despite fierce competition among airlines, safety and training are not competitive matters. Knowledge and techniques that enhance training effectiveness are shared throughout the industry.

The primary educational goals for the development and use of training simulations should be:

Improve situation response time;
Improve decision-making skills;
Reinforce conventional training;
Stress established procedures;
Provide experience in evaluating situations;
Increase resource familiarization;
Build confidence through drills;
Provide cross-training between organizational units;
Stress the need for communication; and

Prepare training for promotion.

WILDLAND FIRE SIMULATORS USED BY BLM IN THE PAST:

Scott projector units, "poor man"

The Scott fire simulator consisted of a series of overhead projectors, a rear projection screen, approximately six instructors (operators), and lots of hard work. Images, being developed in real time by the instructors, were projected on the screen from the overhead transparencies depicting the fire scenario. The trainee incident commander was positioned on the front side of the screen making decisions and deploying available resources.

It was a fairly easy task for the trainee, except for the necessity to make appropriate decisions. For the instructing staff, keeping up with the trainee's inputs and directing the incident to provide a learning experience was labor intensive. Following the simulation, several hours of preparation was needed to prepare for the next run through.

The Scott fire simulator provided a very valuable experience to the learner. However, because of the difficulty and the number of instructors required for the experience, its use has, in all but a few cases, been discontinued by the BLM.

With all the advancements in graphics and computerization, the current wildland fire simulators still have one major problem. They are too labor intensive and require approximately six instructors to operate a simulation for one trainee.

FIRE SIMULATORS CURRENTLY IN USE IN THE WILDLAND FIRE COMMUNITY:

Virginia Department of Forestry's Incident Command System Simulator (ICSS):

John Graff and Jim Copony demonstrated the computer-driven Incident Command System Simulator (ICSS), developed for the Virginia Department of Forestry by V-Graph Inc., on April 7, 1988 in Charlottesville, Virginia.

The simulator is simple in its concept. A visual, that can be obtained from any source, is digitally scanned into an IBM compatible computer. That image becomes the location of the fire being simulated. The trainee Incident Commander (IC) reacts to the simulation as it is viewed on a monitor or projection screen.

A menu is provided at the side of the screen from which basic colors like blue for water, white for smoke, black for char, brown for line, and red for fire are selected by the operator. In addition to the color, the operator also selects a brush size and a color density from this menu. The operator then uses a mouse to draw fire, line, smoke, and burned out areas over the visual to simulate the progress of a fire.

The operator has a monitor that repeats what the IC is viewing. An additional monitor is also used which displays the menu mentioned above, an "invisible window" which is used to provide resources to the IC, and other operator aids. At any time the visual image can be stored on the computer's hard disk for future use.

Communication between the IC and dispatch, the crew supervisor, the engine foreman, etc. is handled with radios. The current system requires one radio operator for each area that will be responding to the IC's requests (up to six stations available).

The delivery for the simulation is a semi-trailer configured with a rear projection screen in the middle. On one side is the computer, the projector, and the instructors. On the other side is the trainee IC with room for a few spectators. The simulation trailer is moved various locations in the state and training is conducted on site.

Alberta Forest Service's Fire Control Simulator:

On August 24, 1989 Dennis Quintilio, Senior Fire Control Instructor, and his associates demonstrated the fire control simulator developed by the Forest Technology School in Hinton, Alberta, Canada. The demonstration was presented in a theater setting where learners are able to apply their knowledge of fire behavior to training scenarios requiring management decisions.

The simulator consists of video segments projected on a large screen depicting: actual wildland fire behavior from ignition to control or project status; the deployment and effect of resources selected to control that fire; and both voice and on-screen visual interaction with key role players such as dispatchers, tower personnel, overhead personnel, pilots, meteorologists, and crew supervisors.

Utilizing laser disc technology, video segments are accessed within a second by either manual control from a keyboard or automatically by depressing the appropriate role player's

microphone switch. A template is placed over the computer keyboard to identify how the keys relate to a set of visuals. A complete wildfire scenario is recorded on the videodisc, along with resources available and values at risk.

Because of the random nature of laser disc technology, only those scenes that relate to the learner's requests and responses are displayed during the training session. Thus, every training session is individualized to the learner.

Voice communication utilizes a closed-circuit radio transmitter, with 4 learner stations and 6 instructor/role player stations. As the microphone is keyed at each of the role player stations a command is sent to the videodisc player to access a visual related to that position. For example, the dispatcher's microphone is keyed and a visual of the dispatch office is projected on the screen. Keying the microphone also triggers an audio cassette player which provides background noise from a dispatch office.

A three-dimensional fire growth model is currently under development which will be added to the system in the future. It will provide the learner with actual contour elevation information and digital forest inventory data for the area of the fire. The model will show the growth of the fire scenario from the ignition point, based on fuel, weather, and topographic information placed in the computer. The learner may also watch a fire line being built between two points, progressing at a rate consistent with the type of resources employed; such as airtankers, dozers, buckets, or ground crews.

This simulator is being used to train incident commanders in Alberta and other Provinces. Six exercises have thus far been developed for use in the simulator.

EFFECTIVENESS:

A review of the literature regarding the effectiveness of simulations for training, combined with actual field test results from the Fire Behavior interactive videodisc instruction (IVI), reveals the following conclusions:

1. Students generally acquire at least equal knowledge and intellectual skills as they would in other learning situations.

2. Information is learned faster than in other methodologies, though the amount learned is not significantly greater than with other methods.

3. Students of low academic ability often improve their performance because of greater interest.

4. The use of games and simulations increases problem-solving ability.

5. Discussion aids participants' satisfaction with simulations.

6. Students will be motivated to participate in the activity, but their interest in the subject may not be improved.

7. Simulation helps remove instructor/student polarization, thus reducing personal tensions and antagonisms.

8. Games and simulations have great impact on affective learning.

9. Simulations stimulate students' feelings of competence and self-confidence.

10. Simulations develop decision-making skills (Butler, 1988).

Fire Behavior IVI Field Test

Although not a simulation, the results of this CBT field test indicated clearly that learning took place at an equivalent or higher level than in the classroom versions of the same course. Learners preferred learning at their own pace utilizing the computer-based instructional format.

(See attached test results chart: Videodisc Field Evaluation Performance)

A letter from the Assistant Chief of Fire Management, Virginia Department of Forestry, to the National Capitol Region of the National Park Service, relates the effectiveness of simulations used over the years in Virginia.

The Department of Forestry has been continuously using forest fire simulators to train its personnel, fire departments, forest industry and other cooperators since the early 1960's. Scott projector units, "poor man" and now computer-generated simulation has been used as technology has evolved. Fire simulation is an absolute must to train incident commanders and staff members to apply their knowledge and skills learned in on-the-job training and

classroom training. Without this bridge between basic training and fire incident command or staff function on an actual fire incident, many unnecessary misjudgments and mistakes would occur jeopardizing life and property.

My personal 30-ear experience using the forest fire simulator to train Department, fire department, forest industry and other cooperators has made me a staunch supporter of this training. I have seen the training transform disorganized, ineffective, and unsafe attacks on fire into organized, effective, and safe operations. In the process the average acreage burned per fire has been dramatically reduced.

The Department is committed to training 600 fire departments, forest industry and other cooperators using two computer-generated, mobile forest fire simulator units. Each cooperator is scheduled for the training at least once each three years. Department personnel receive annual training. The units are moved and operated by training teams organized in each of the Department's administrative regions.

A comparison of the number of forest fire incidents, average acreage burned, and cost of fire control between Virginia and other Southern States and Federal agencies is a vivid confirmation of the success of the forest fire simulation program in Virginia.

DESIGN ELEMENTS:

Having established the uses and effectiveness of simulators in training, as well as BLM's requirements for simulation training, some of the design elements should be considered.

Most instructional designers agree on the following elements of simulation design:

Experience is the best teacher. The simulation should duplicate the experiences and responses of the real world as faithfully as possible.

Feedback should be limited to the realistic response of the equipment or real life situation. No special effects are necessary.

Learner control should be bounded by the natural range of responses contained in the real situation. For simple machinery, the accepted responses may be few and limited to flipping several switches. In more complex

or ambiguous situations, there would be a wider range of learner options paralleling the natural choices.

Subject content should be sequenced by the order inherent in operating specific equipment or accomplishing real life tasks. Subject content should be random when order and sequence are not critical.

The learner must be in control by interacting with the simulation, to determine the level and intensity of instruction received (Paske, 1990a).

TECHNOLOGY:

Equipment, Software, etc. Needed for Development and Operation:

Computer

IBM AT compatible computer with a minimum of 640K of RAM memory, a minimum of 40 MEG harddrive, with an EGA or VGA color card.

Monitors

Compatible with the IBM 3270 and IBM AT and PS/2 microcomputers using CGA, EGA, PGA, MDA and VGA.

Super fine pitch character display with an anti-glaring dark screen.

An RGB terminal which allows equipment with either analog or digital RGB output to be connected.

Two examples

Sony CPD-1302 VGA Color Monitor
NEC Multi-Sync 3D VGA Color Monitor

Videodisc and Players

Interactive videodisc is uniquely suited to capturing people's attention through the use of real footage while simultaneously reinforcing skills and tactical expertise. The interactive videodisc is presently the only purchasable means of presenting an interactor with a fully developed work of multi-media. Fully developed means a work that combines full-screen, full-motion

high resolution video in color, with stereo sound, computer-generated animation, text, and a computer interface that allows the interactor to intuitively navigate through a randomly accessible audiovisual database with ease.

Other systems based upon the compact disc technology will no doubt eventually replace the videodisc, but for the immediate present the videodisc is the only game in town(Paske, 1990b).

Pioneer Model LD-V8000

The Pioneer model LD-V8000 laserdisc player has four audio channels. Two digital audio tracks and two analog audio tracks which can be played back simultaneously or independently. Four channels allows four languages to be used, four levels of presentation to be given, or four hours of random access audio which is available with or without a visual from the disc.

The LD-V8000 has a two field digital memory. One visual image can be held in memory on the screen while the laserdisc player searches for the next image for a seamless transfer or another audio track to amplify the still frame visual. Audio from the laserdisc can also be played to amplify a screen containing computer-generated text or graphics.

Sony Model LDP-2004

The Sony model LDP-2004 is also heavily used with interactive videodisc instruction and computer-based training programs. The Sony has most of the features mentioned with the Pioneer. It utilizes the Sony SMI-3081 interface card for access by a computer.

Video Interface Card

Sony SMI-3081

High Scan Superimposer consisting of a superimposing board and a VGA color graphics board. Provides an interface between the NTSC composite signal from a videodisc player and computer-generated RGB computer-generated graphics. This enables video and computer-generated images to be mixed or overlayed on a video monitor.

This interface card requires two 16 bit expansion slots in most AT compatible computers. It provides graphic resolution of 640 x 480, with a 256 color palette. The system is also backwards compatible with materials developed utilizing CGA and EGA graphics.

The SMI-3081 supports Sony videodisc players.

Visage V:Link 1910

A videodisc control and VGA graphics overlay board provides an interface between the NTSC composite signal from a videodisc player and computer-generated RGB computer-generated graphics. This enables video and computer-generated images to be mixed or overlayed on a video monitor.

This interface card requires only one 16 bit expansion slot in most AT compatible computers. It provides graphic resolution of 640 x 480, with a 256 color palette. The system is also backwards compatible with materials developed utilizing CGA and EGA graphics.

The V:Link 1910 supports Hitachi, Pioneer, and Sony videodisc players. It can also be internally linked to the Visage V:Link 1800 digital audio board.

Audio (Digital or compressed)

Both the Virginia Department of Forestry's ICSS simulator and Alberta's Fire Control Simulator requires one radio operator for each instructor/role player station. By modifying these simulators so that voice communication could be controlled by the same operator that controls the computer inputs, the simulator would then require only one operator.

Voice communication could be digitally recorded on the computer's hard disk or compressed on the videodisc. When the operator receives a request from the trainee a menu would be accessed with a mouse or key stroke, then the proper response selected and transmitted to the IC. A variety of voices could be used to add realism.

With such a modification incorporated, training could be conducted in a trailer, a classroom, or from both ends of a long table, making it a truly portable training device. Various systems to provide these audio needs are listed below.

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Visage V:Link 1800 Digital Audio Board

The Visage V:Link 1800 digital audio board provides recording and playback of digital audio segments using an IBM XT/AT compatible computer. The audio is "captured" digitally and stored in standard DOS file format on floppy diskettes, hard disk, or CD-ROM.

Digital filtering and real-time compression techniques similar to those used in compact disc players enable high-fidelity audio to be recorded without requiring large amounts of storage (1/2 hour of voice grade audio requires 7 megabytes of memory). Sample rates can be monitored before any audio is recorded. Independent gain and connection controls are available for six audio inputs and three audio outputs.

Dolby Labs' Model 500 Digital Encoder/Decoder

Dolby Labs' model 500 encoder/decoder for digital audio uses advanced compression algorithms to improve storage density. 6:1 time compression without limiting dynamic range could be used to store two hours of stereo sound on a 3-inch CD, or increased times for PCM and digital formats.

Fast-Trax Digital Technologies' SES-300/PCAT-300 is a still-frame audio encoder/decoder. 300:1 data compression results in storage of 10 seconds/frame on videodiscs. This translates to 150 hours of audio on a 54,000-frame disc. This technology provides the convenience of mingling video, data and audio on the same disc (Rising, 1990).

Compressed Analog Audio

Still-frame audio is a relatively new compression technique being offered by several companies including Sony, Matrox, and EECO incorporated, of Santa Ana, California.

Essentially, still-frame audio allows an audio signal to be changed into an analog video signal and stored as a still frame on the videodisc. During this conversion process, the audio is compressed by a ratio of 300 to 1. This allows up to 10 seconds of voice-over narration to be placed into just a single frame on a videodisc. With 54,000 frames per disc, that allows up to 150 hours of audio to be recorded on each side of a

disc, as opposed to only 30 minutes of audio per side on a normal videodisc.

The EECO company's method for still-frame audio requires two pieces of equipment: an encoder and a decoder. EECO's encoder, the AVC-300, is an expensive piece of equipment found in many video post production facilities. The use of it is hired by the hour--usually for $200-$250 per hour. It takes almost a full day of studio time (approximately $1500) to transfer 70 minutes of audio. Contained on a master 1/4-inch tape, all the audio for the disc was edited onto the premaster videotape one frame at a time.

To play back this compressed audio-on-video, an EECO decoder model VAC-300 is required at a cost of $1800 each. The VAC-300 connects to just about any microcomputer through the RS-232C serial port.

The EECO Company also markets a PCAT-300 board that can be installed in a microcomputer. This board provides continuous audio, and increased frequency bandwidth. Choose between 11 kilohertz and AM radio-quality 3.4 kilohertz. This board has the ability to upload and download digital audio when course updates are needed. Ordinarily, updating a videodisc requires remastering. With the PCAT-300, audio updates can be uploaded from floppy diskette.

The Online DSA-320 and the Antex vp-635 systems also provide compressed audio capabilities (Larson, 1988).

RECOMMENDATIONS

Based on the review of literature, operating simulations, the positive results being achieved using simulations for training (especially for life threatening situations), along with the technology that is available, the recommendation of this paper is to press forward with the development of a wildland fire simulation for BLM. Two options are listed below.

First: Modify and combine the features and techniques of the Virginia and Alberta simulators to provide:

Randomly accessible video footage from a videodisc. Footage accessed either by the instructor using keystrokes or mouse, or by pre-programmed responses to input.

Computer-generated graphic representation of the location and behavior of the fire, providing current overall status to the incident commander.

Computer-generated graphic representation of resources being deployed by the incident commander and their effectiveness.

Compressed or digital audio to provide voice communication and responses to the trainee incident commander. Appropriate responses to be selected by the operator from a menu of pre-recorded options and transmitted to the trainee.

One operator (instructor) to provide training to one incident commander (trainee).

Trainee and instructor interaction accomplished by a radio similar to what would be used on an actual incident, to provide a touch of realism.

Feedback and evaluation of the exercise would be provided by the operator.

Second: Develop a completely new CBT simulation similar to SimCity to provide:

Computer-generated graphic representation of the location and behavior of the fire, providing current overall status to the incident commander.

Computer-generated graphic representation of resources being deployed by the incident commander and their effectiveness.

Digital audio to provide voice communication and responses to the trainee incident commander.

A completely self-contained and trainee driven simulation with no operator.

Trainee utilizes a keyboard or mouse for input to the simulation.

A game format with unlimited variations, encouraging frequent use and mastery of tactics and procedures.

Feedback and evaluation of the exercise would be provided by the simulation program throughout the exercise as well as an exercise summary at the end.

A CBT MODEL TO WORK FROM

SimCity is both a game and a CBT course. While it is mostly marketed as a game, winning numerous awards in 1989, it has all the elements of CBT. It uses interaction, feedback, and simulation to teach. Even though the topic is not a particularly interesting one, millions of computer gamers now know the basic principles associated with zoning laws, setting up a transportation system, organizing a police and fire department, setting up an urban tax structure, and distributing city funds.

The same techniques and similar computer program could be used to teach the principles of wildfire fire behavior, fire behavior tactics, and the responsibilities of an incident commander.

Users of SimCity create their own city and make all the major decisions. They clear land for building, and decide with zoning what will be built there. They decide where to place police stations, energy plants, airports, and parks. They build roads and lay tracks. They also establish taxes and distribute revenues.

Users of a Fire Behavior simulator would decide where to place control lines, what resources to order, where resources are to be deployed, where to establish fire camp, etc. Times associated with travel, cutting control lines, aircraft support are calculated by the program based on actual time frames.

Control over the SimCity is not dictatorial. An area can be zoned for industrial growth, but fail to develop due to poor transportation systems or other inhibiting factors. A suburban district might be planned, but end up as high-rise apartments and condos developed by property speculators. Building a high-tech nuclear energy plant could solve the city's energy problems or cause nearby residents to start moving out as property values plummet. And when everything is finally going perfectly, an earthquake or major fire hits SimCity to test it's ability to recover from a natural disaster.

Likewise an incident commander can develop and implement a plan for suppression, effectively utilizing all available resources. Deploying hand and engine crews to cut off the head of the fire with a line anchored to natural barriers. Then, just when the incident commander has everything under control, the wind shifts and pushes the fire in a direction that is least defensible and the fire is in danger of being

lost. Using weather information from a weather data base that can be randomly accessed or weather information that has been entered prior to the exercise, the exercise can test the incident commander's ability to recover from radical changes in fire behavior.

The real strength of this simulation is that the incident has a life of its own. Users don't just answer a set of questions and then receive a score. They simulate the suppression of a wildland fire incident that changes over time. As it grows tactics must change and resources must be deployed or repositioned to adapt to the changing conditions.

If a problem, like spotting, starts fires across an established fire line, users can adjust the plan of attack to extinguish the spot before it gets out of control, if there are enough resources available. The payoff would be a fire that is contained and controlled with initial attack resources.

For an added challenge, it would be possible to start as a replacement incident commander on a fire that has escaped initial attack. The user would assume the role of the multi-resource incident commander and undertake the responsibilities of a project fire.

SimCity teaches basic principles of city planning. For ease of use, it presents the game's maps and other information in windows that are easy to move through. The user makes decisions and gets information through simple menus which use pictures to identify choices rather than words.

The wildland fire behavior simulator could utilize a similar menu system. For example, the user moves the cursor to a picture of a handcrew and taps the space bar or mouse button. The user then moves the cursor to the area of the map where the handline is to be cut and identifies points along the proposed fire line. With another tap of the space bar or mouse button the handcrew begins to cut line at a pace equivalent to the time it would take an actual crew to cut line in similar terrain.

With clear, easy to use, and interesting graphics, the whole fire complex can be fully animated. The user sees vehicles moving in and out of fire camp; firefighters eating meals, picking up supplies, filling out time reports, sleeping, etc.; handcrews, fellers, and dozers cutting fire lines; engine crews putting

water and/or foam on the fire; and resources being deployed. If the incident commander does not deploy available resources accurately the fire will escape, requiring the formation of new tactics an possibly additional resources.

In terms of instructional methodology, SimCity has a very effective method of teaching the principles of good city planning -- pure trial-and-error.

The limited game instructions tell the user how to build subdivisions and football stadiums, but says almost nothing about where to put them or where the roads and parking lots should be. In fact, the theory or accepted rules of city planning are mentioned only briefly in four pages at the back of the instructions. SimCity has none of the traditional "text screens" or "detailed feedback" requiring the user to read. The result is much higher retention of the material learned. People remember what they discovered for themselves better than what they hear or read. However, text and other instructional screens can be included as necessary for appropriate feedback and information.

A wildland fire simulator would never tell the incident commander how many fire lines to build or where to build them. But if a section of the fires perimeter is not contained, the fire will escape and additional time and resources will be unnecessarily spent. Most importantly, as the fire expands or the incident commander tries new exercises, the user will learn to place fire lines where they can prevent a problem from repeating.

Feedback, Reinforcement, and Learning

The simulator gives users tools to measure their current success or failure. At any time they can see a summary of acres burned, resources at risk, resources lost, resources available, etc. If the exercise is a large project, public opinion would be a factor. But the real measure is the fast or slow growth of the fire and the resources lost to the fire.

So for every failure, the user learns how to do the job better in the future, and for every success gets positive feedback and reinforcement on what has been learned. After playing the game for a while, a basic understanding of wildland fire management strategies develops. This understanding will be as good as that

of someone who read a textbook on the subject, or better.

But the real strength of a CBT simulation is that it is fun and easy to use. If users have fun, they will give the simulation/game a lot of attention. They will invest a lot of emotion into it. And they will have very good feelings about the experience. This, in turn, translates to high motivation to use the simulator, high motivation to learn from it, and high retention of the principles learned.

Due to budget limitations, this Fire Behavior simulator may not have the detailed graphics, animation, and elaborate interfaces of SimCity. These bells and whistles are nice but not really necessary. All most CBT courses need is to be user-friendly and visually pleasing, both of which are possible with a realistic budget and a little creativity.

SimCity's instructional technique of training by trial-and-error is definitely possible. Start with the complex simulation. If the learner is having trouble, give the usual feedback, but also give the learner the option to read the relevant text material. You can then branch the learner back to the simulation, if it is complex enough to be valuable a second time, or to a second simulation. Or, alternately, you can branch the learner to a simpler simulation until skills are more fully developed. If the learner is still having trouble, the course repeats the process making the text material mandatory this time.

This strategy employs all the same elements as a traditional simulation course with the added effects of branching. Learners who already understand some of the concepts will automatically bypass material they don't need. Learners who need extra help will be branched to a repetition of the problem material. The results is a simulation that is very time effective for the learner. The course's main simulation becomes a pretest, a mastery test, a motivating tool, the main teaching tool, and a branching menu, all in one.

In reality, the difference between good CBT, challenging simulations, tests, and games is very slight. SimCity is fun and challenging, and it teaches the concepts very effectively. But while it is sold as a game, it's really a CBT simulation which would serve as an excellent model for a Fire Behavior simulation (Cooper, 1990).

WHAT'S IN THE FUTURE

What technology is providing for simulation training today is very impressive, but a look into the future can easily boggle the mind.

Virtual reality (VR) is a relatively new, real-time graphics and animation technology that immerses users into alternate worlds, ones that seem as real as the real world. The user will be placed into a given training environment by wearing a scuba mask-like device that uses small LCD panels to project separate stereoscopic images for both eyes.

Through a combination of sensing and interface devices and software, VR systems provide direct interaction with computer-generated three-dimensional models. This is done by a very powerful CAD hardware/software system capable of rendering sophisticated graphic scenes at close to 30 frames per second, approximately real time.

One of the leading developers on the field of VR research is NASA. The agency hopes to train astronauts working in a weightless environment to use tools as well as operate the Manned Maneuvering Units.

At the University of North Carolina, computer scientists have used architects' plans to create a detailed, realistic model of a proposed building. In virtual reality, the architect can walk through the building and see exactly how it will look and feel when it is built. If there are problems with the architect's design that were unforeseeable from a crude blueprint, he can see them and change them, thus preventing costly mistakes.

When it comes to training, a VR system could be used to plunge a student into just about any training environment and simulate any task. For example: different types of trees could be represented visually as a forest. You could actually walk into the forest and touch each tree or view the forest from an airplane or a mountaintop to get the big picture. You could notice groupings of trees and see instantly the relationships between the various species, and quickly access forest management records.

One of the most powerful instructional aspects of VR is the ability for a teacher or expert to see with their own eyes what the student sees, providing unparalleled instructional opportunities. Anything you can image is possible in virtual reality. Its only limiting factor is the imagination of its user (Fitz, 1990).

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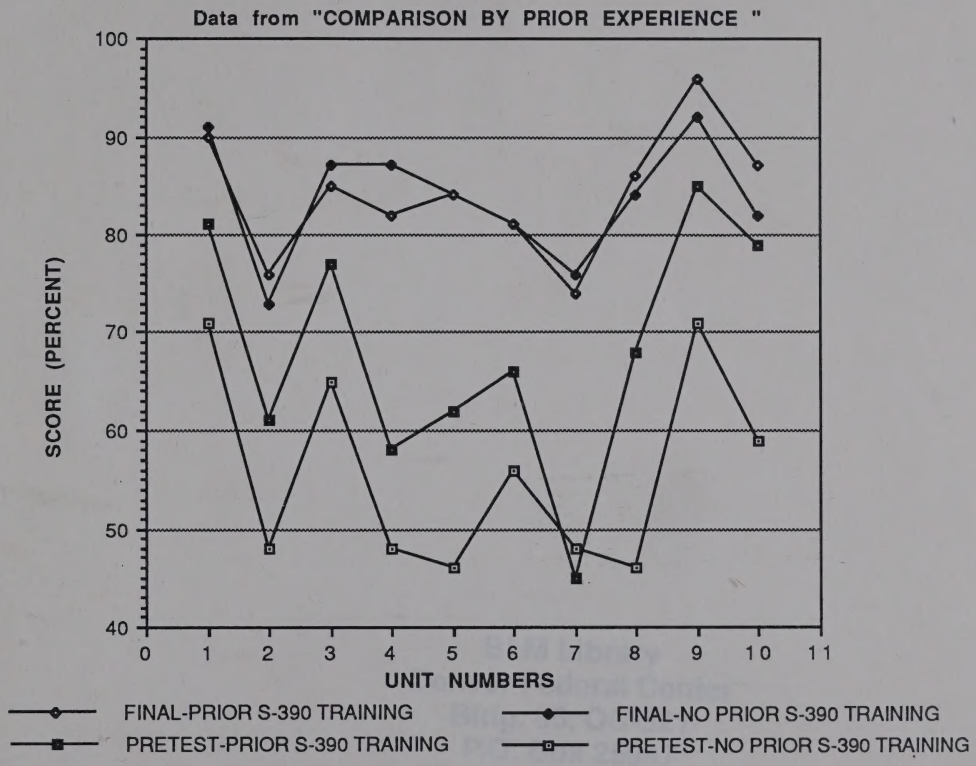
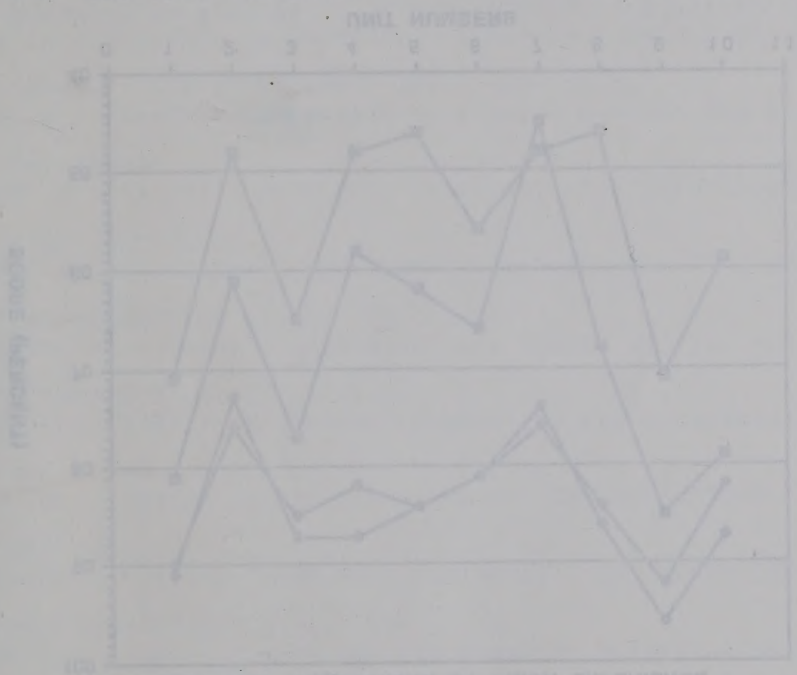
VIDEODISC FIELD EVALUATION PERFORMANCE





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